Monitoring aerosol sources, transport, and climate impact using A-Train observations and modeling

Michael Schulz

Contributions from
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MetNo- Norwegian Meteorological Institute

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Acknowledgments go to
A-Train team
A-Horse (AeroCom modellers, slow, need fodder)
A-Base (Aeronet team)
A-Source (CNES, NASA, EU)

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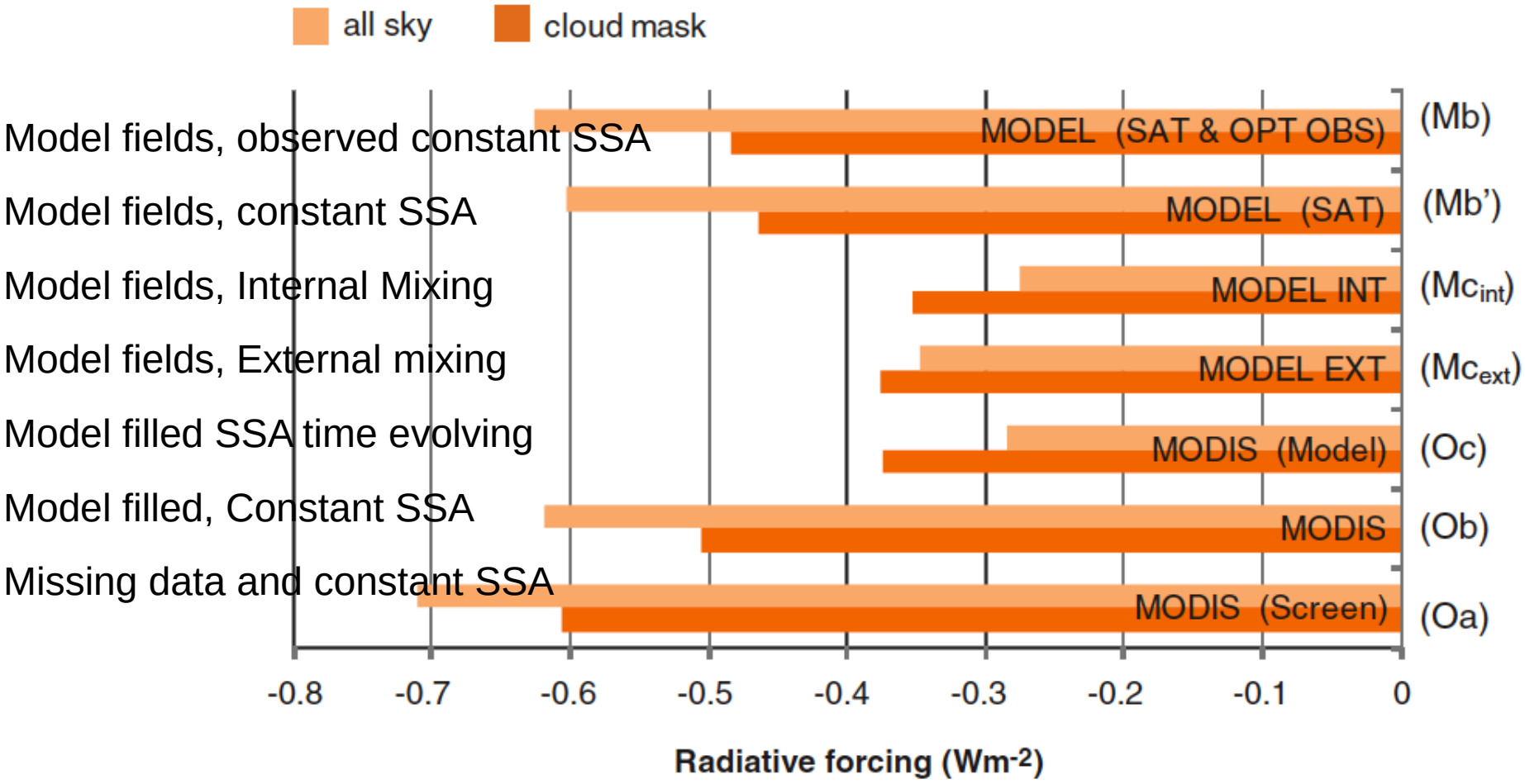
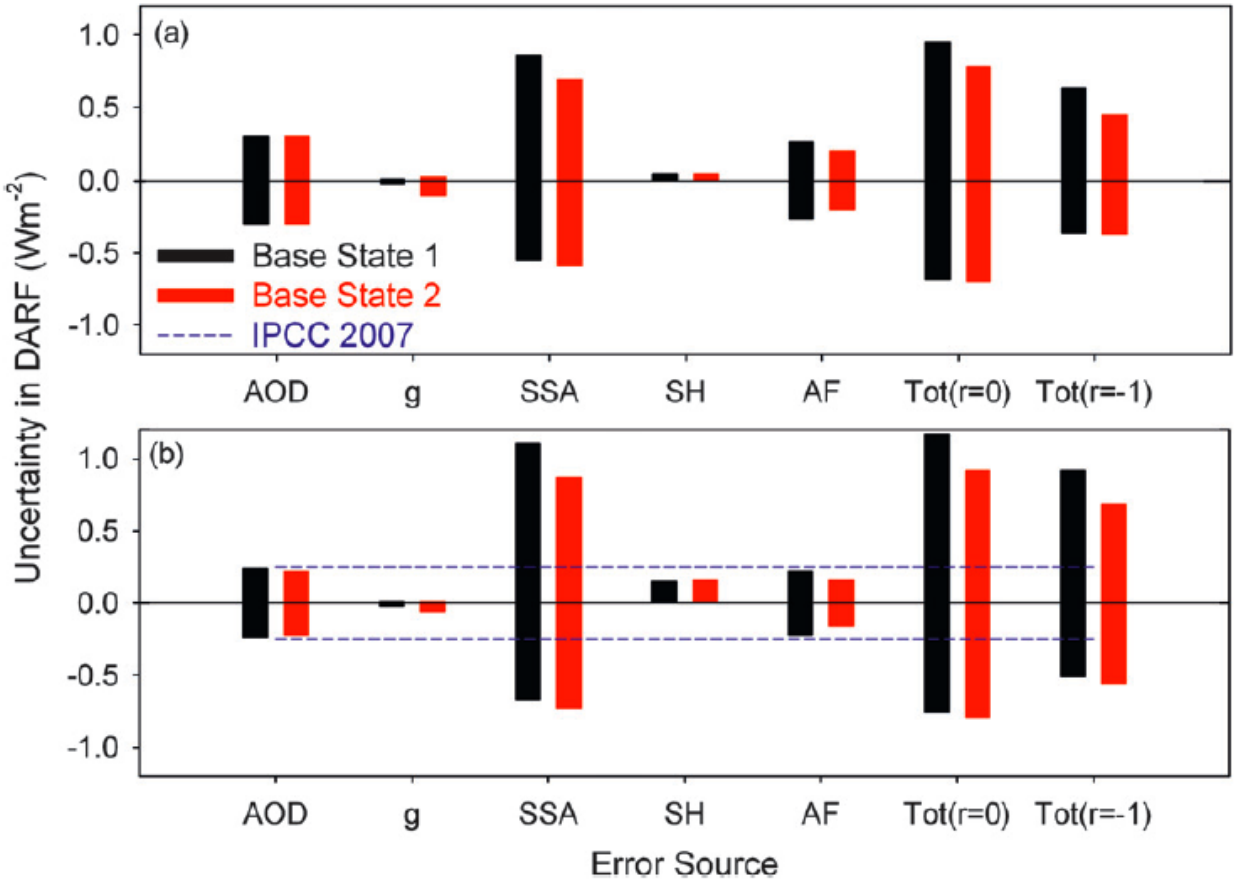
Trying to be consistent
Using Modis Terra & Aqua and UIO CTM model



Myhre et al., Science, 2009

Loeb & Su, J Clim, 2010
…RF is largely underestimated by IPCC



CLEAR SKY

ALLSKY

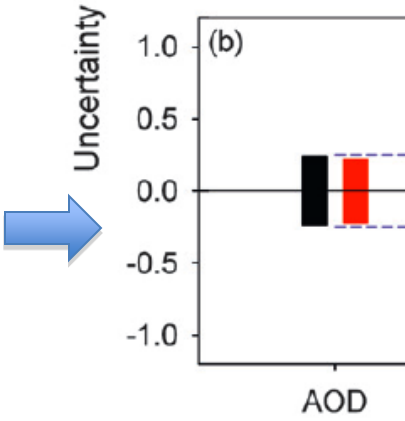
Loeb & Su, J Clim, 2010
…RF is largely underestimated by IPCC

Using data from this study:

Direct radiative effect, present day

3.5 Wm-2 / 0.16 AOD = 25 W m-2 per unit AOD

=> 0.01 AOD error leads to +-0.25 Wm-2 uncertainty



Anthropogenic AOD and forcing

-0.37 Wm-2 / 0.0055 AOD = 7 W m-2 per unit AOD

=> 0.01 AOD error leads to +-0.07 Wm-2 uncertainty

Outline

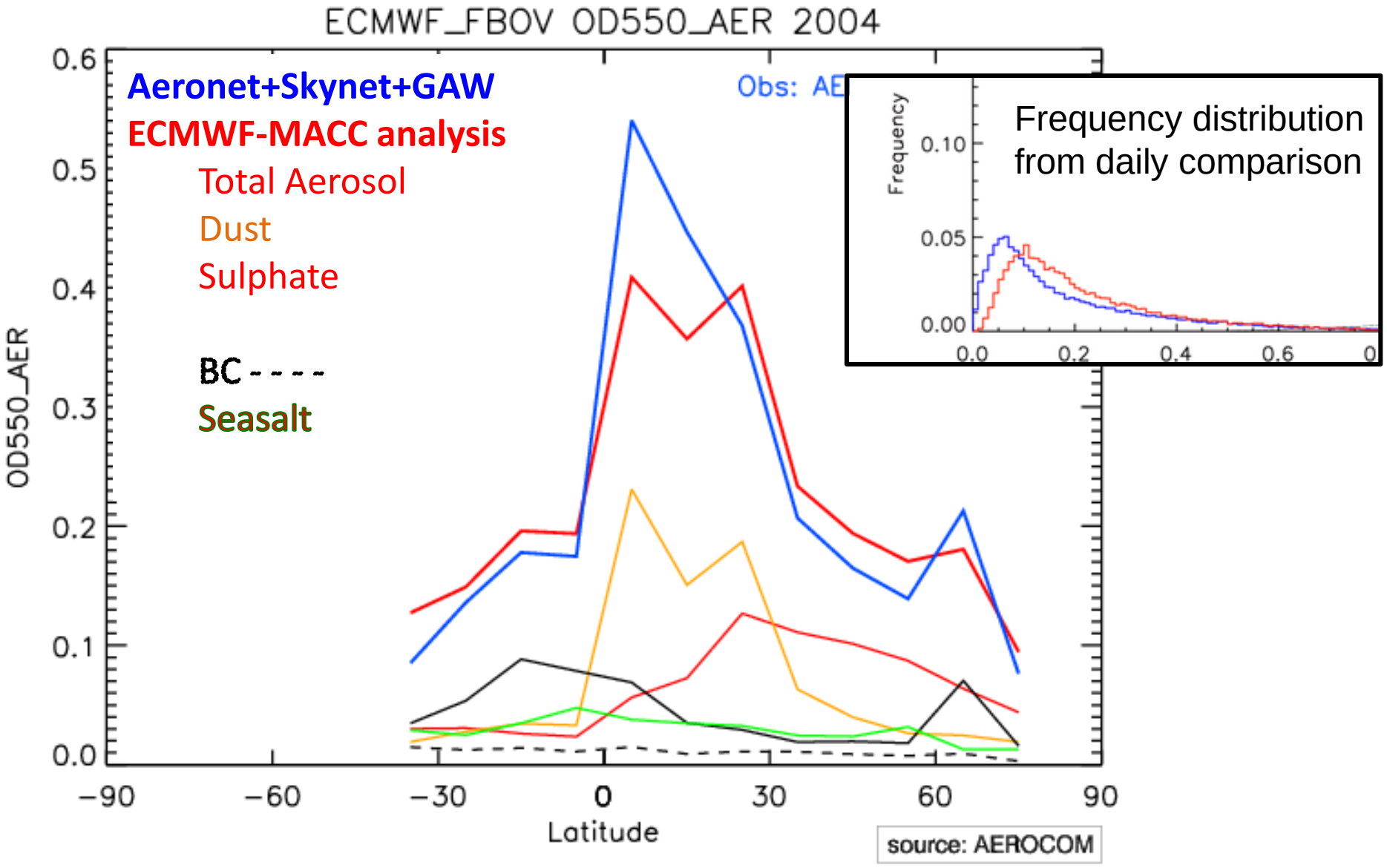
- How well do we know global AOD?
- Do models reproduce the vertical distribution of the aerosol?
- Do we understand regional emissions&trends?
- Challenges

How well do we know the global mean aerosol optical depth AOD ?

Why is that interesting?

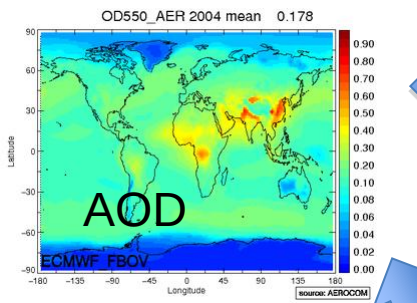
- Direct radiative effect is nearly proportional to AOD
- With SSA known, BC radiative effect is constrained by total AOD
- If global AOD from satellites can be trusted then
  Regional model bias established against satellite AOD fields contains information on emission understanding
- Climate aerosol interaction understanding
  involves knowing both the natural and anthropogenic aerosol

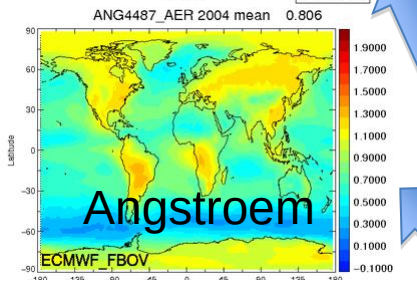
Latitudinal distribution of assimilated and observed AOD

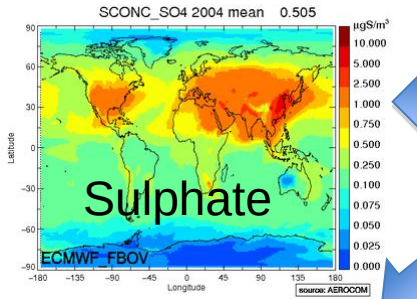


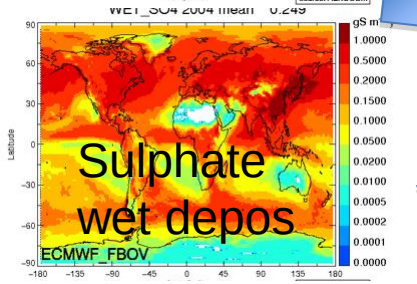
MACC versus Aerocom Median

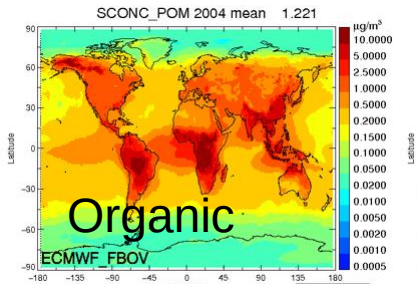
Correlation vs Obs	MACC	Aerocom Median
AOD	0.84	0.77
Angstroem coeff.	0.75	0.73
SO4 surface conc	0.58	0.70
SO4 wet dep	0.59	0.66
POM conc.	0.38	0.69
Seasalt conc.	0.83	0.75

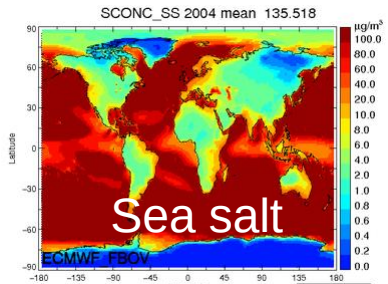


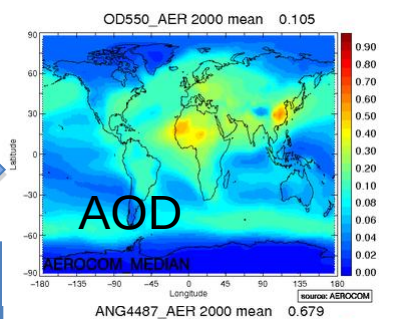


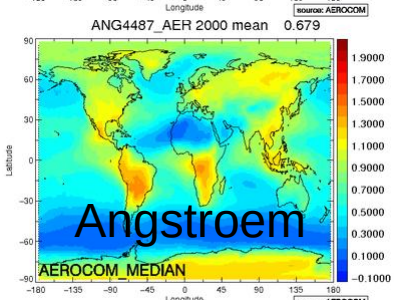


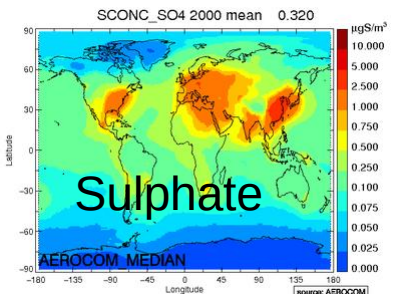


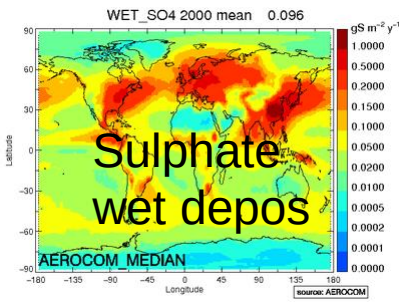


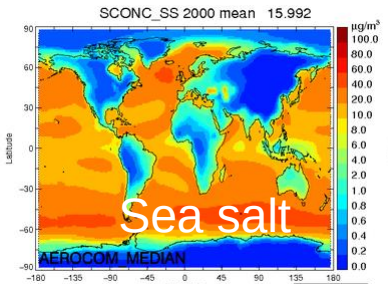


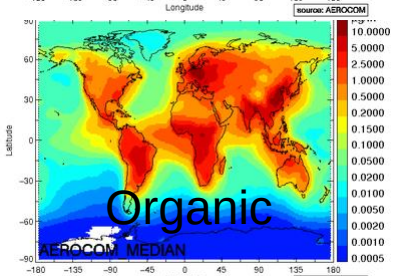




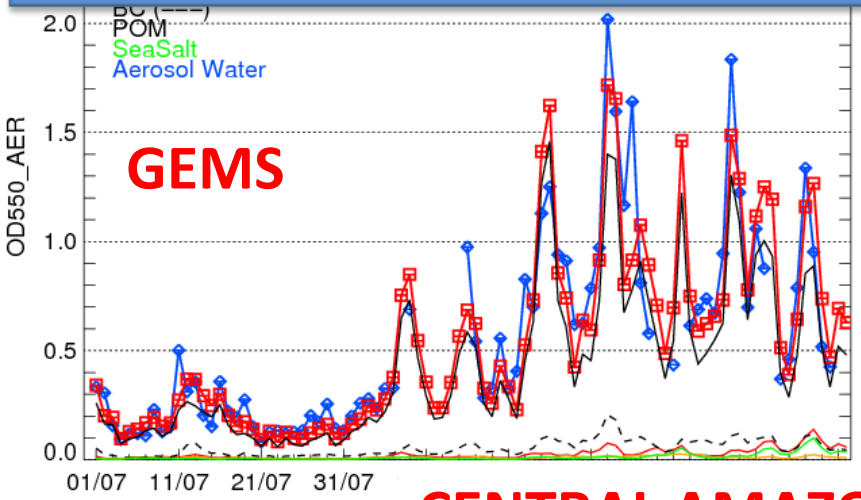


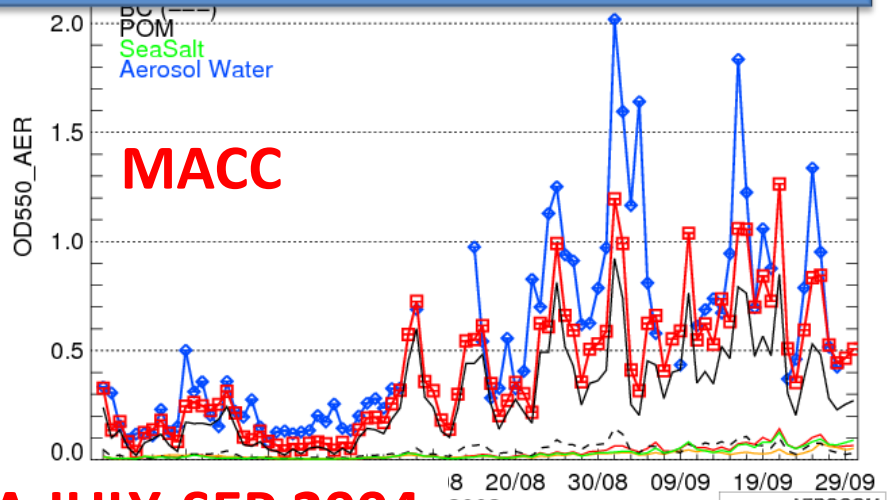




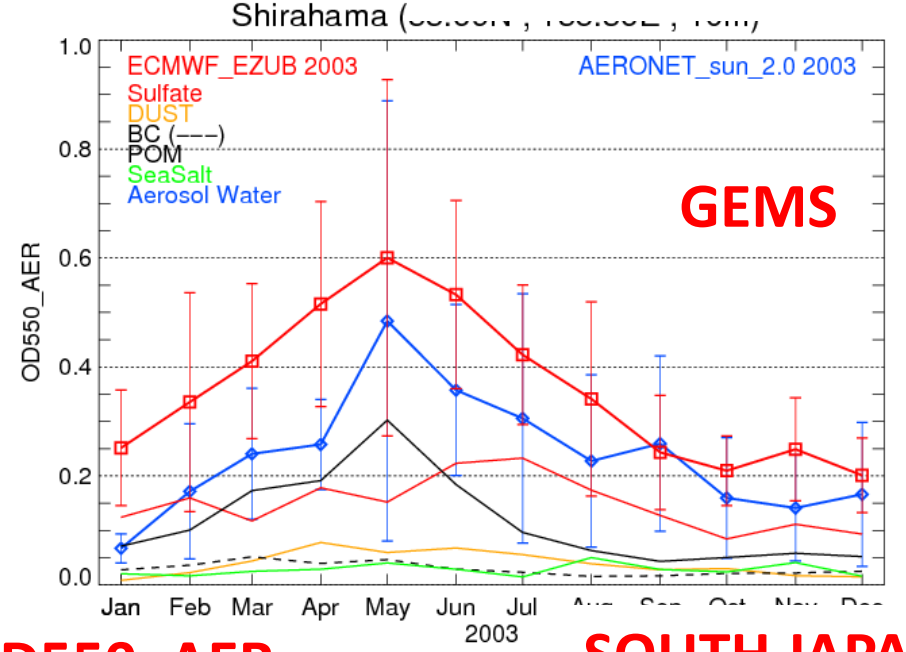


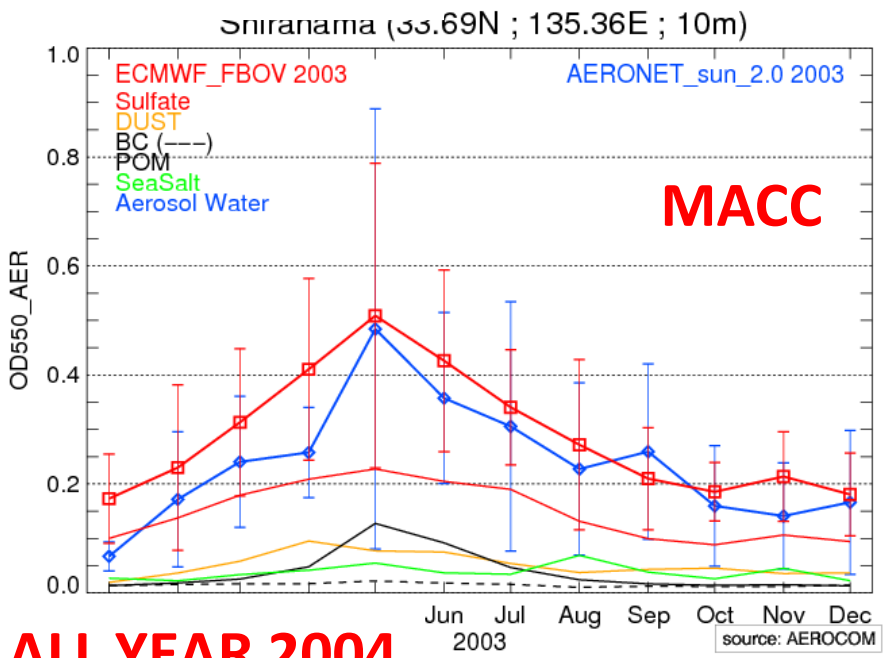
Impact of a-priori model assumptions in two assimilations
Emissions changed….GFED2 (GEMS) versus GFED3 (MACC)





CENTRAL AMAZONIA JULY-SEP 2004





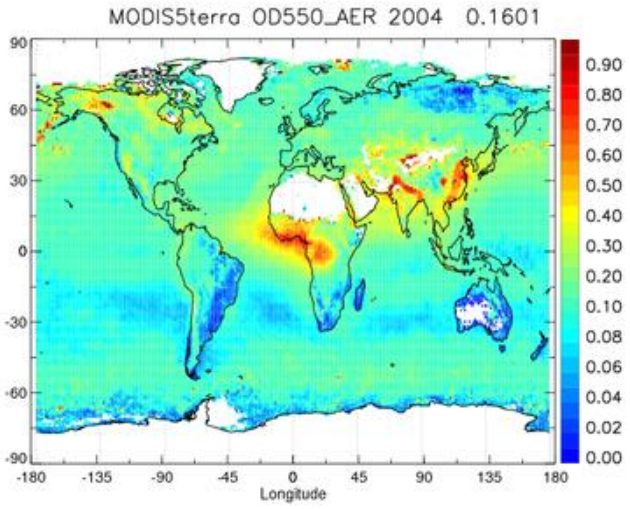
OD550_AER

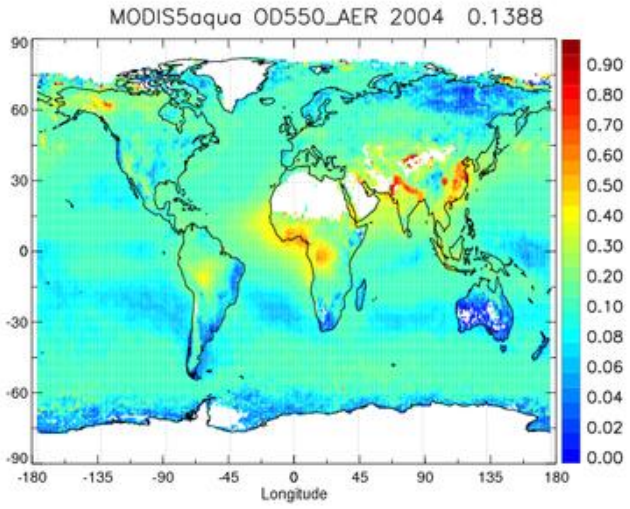
SOUTH JAPAN ALL YEAR 2004

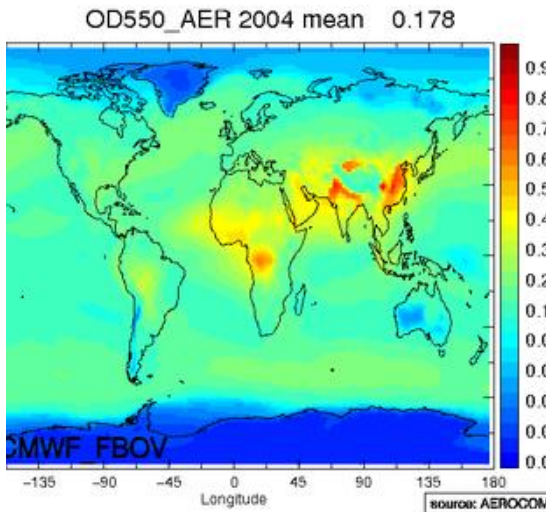
How well do we know the global mean AOD

MODIS aqua, collection 5, 2004	0.139
MODIS terra, collection 5, 2004	0.160
Parasol , 2006, over ocean	0.157
MACC assimilation Terra&Aqua, 2004	0.178
Aerocom Median (Aerocom phase I) 2000	0.105
Best guess	0.17 +-0.01 = 5%

(sea salt belt, higher AOD over land, missing dust in MODIS,
old Aerocom low, Assimilation high if MODIS biased,)





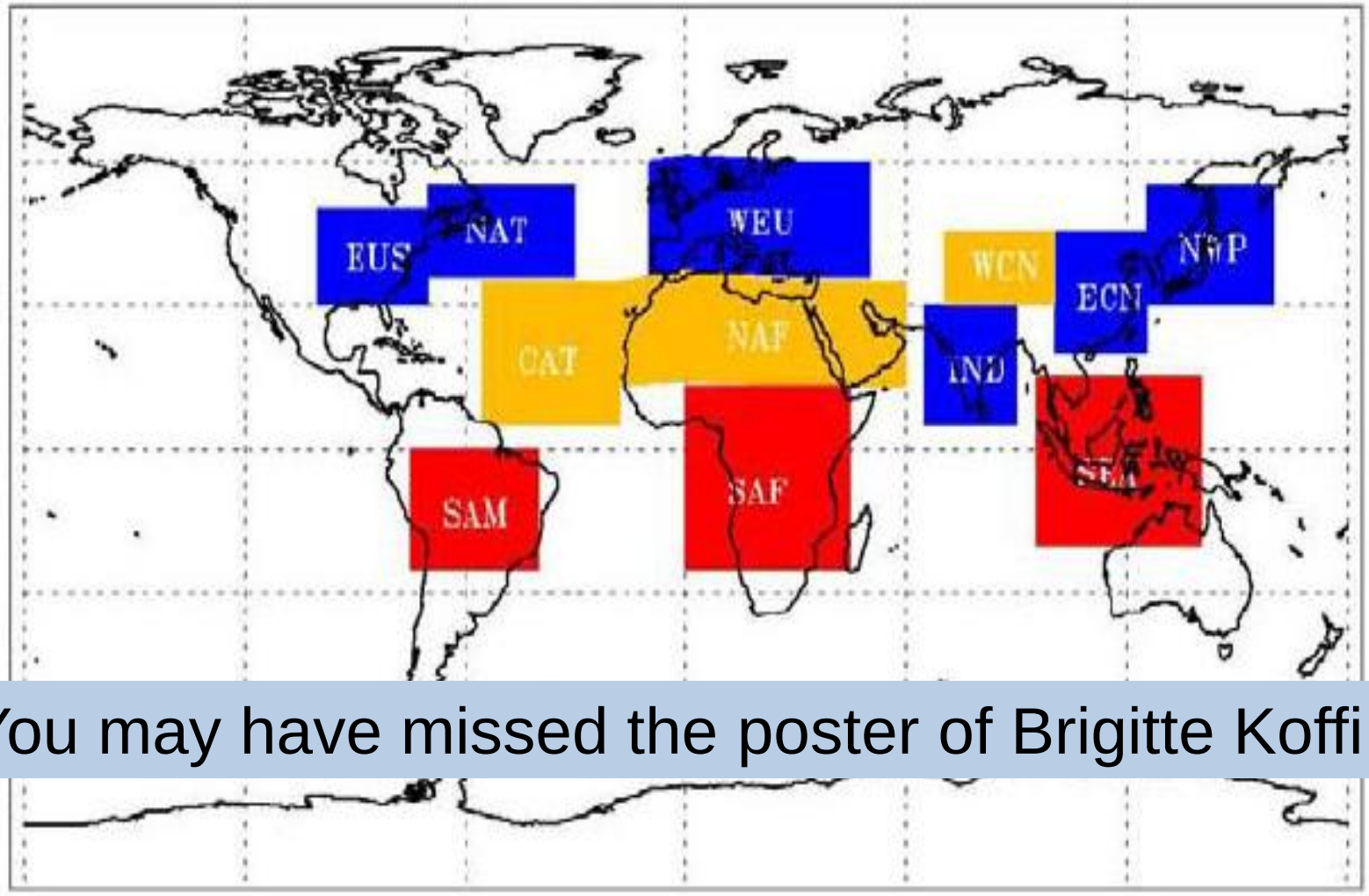


Do models reproduce the vertical distribution of the aerosol?

Why is that interesting?

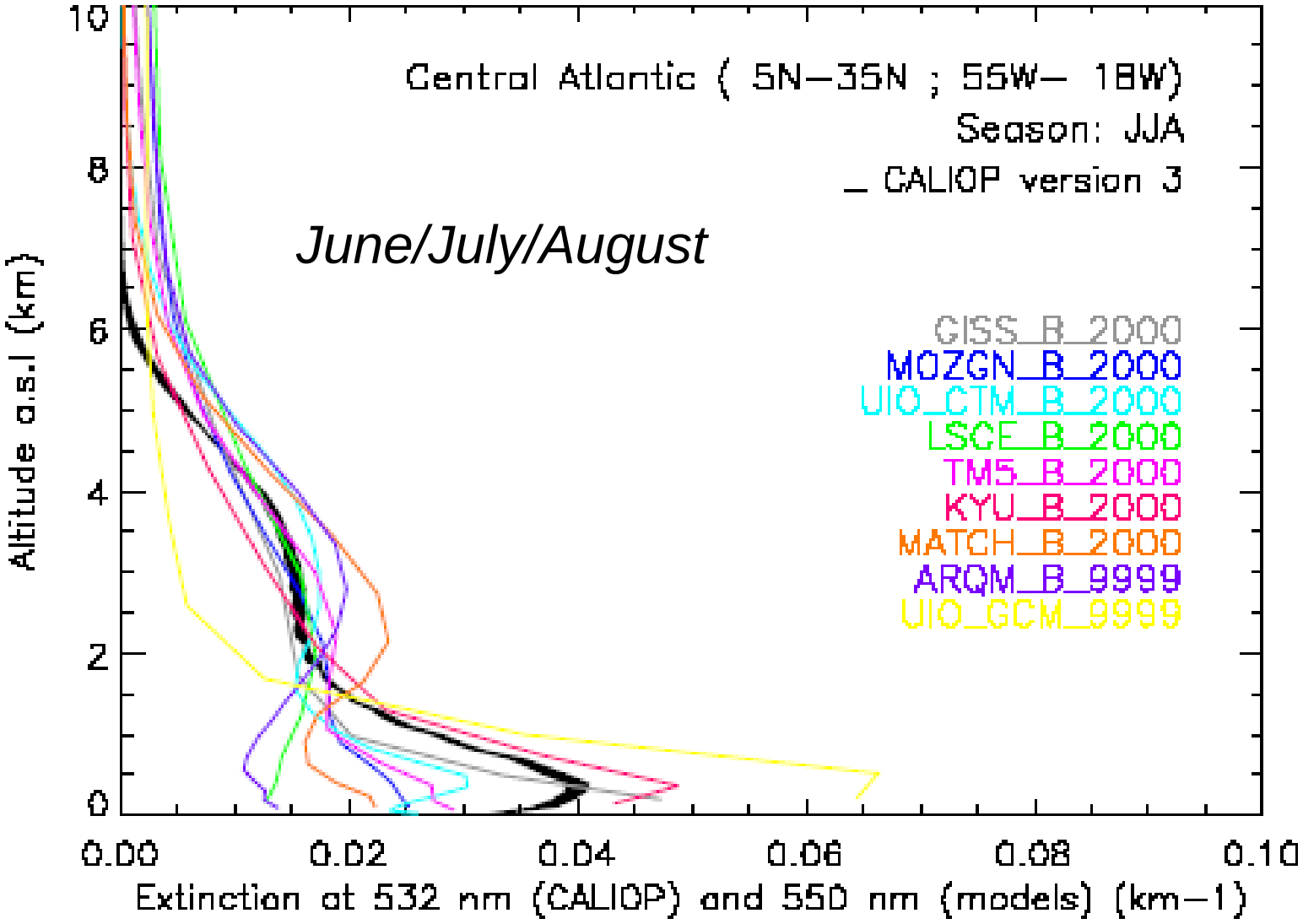
- Direct&semi-direct forcing by absorption above clouds
- High aerosol is subject to long range transport and less removal
- Air quality applications require relations surface PM / AOD
- Humidity growth is smaller at altitude with forcing consequences
- Vertical distribution reflects balance between surface emissions, secondary aerosol formation, vertical dispersion and removal thus regional climate and aerosol interactions

Comparison of Regional Averages of CALIOP and Models Nighttime Aerosol extinction layer product, CAD screened *following Yu et al., 2010*

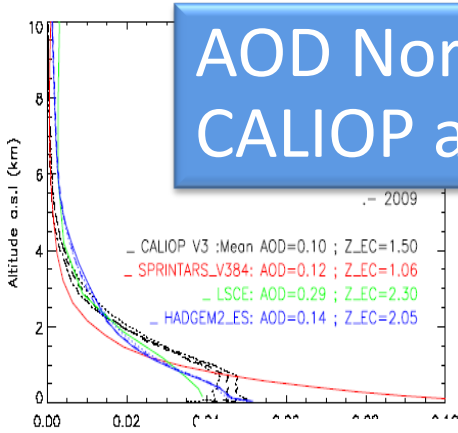


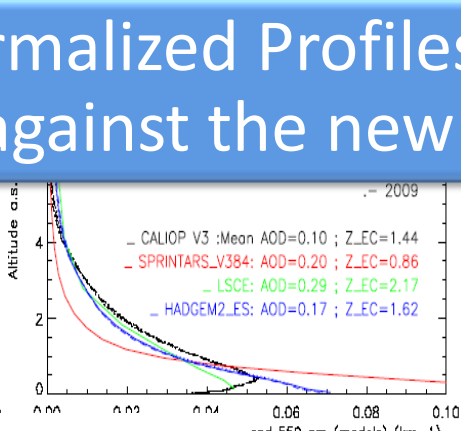
=> You may have missed the poster of Brigitte Koffi….

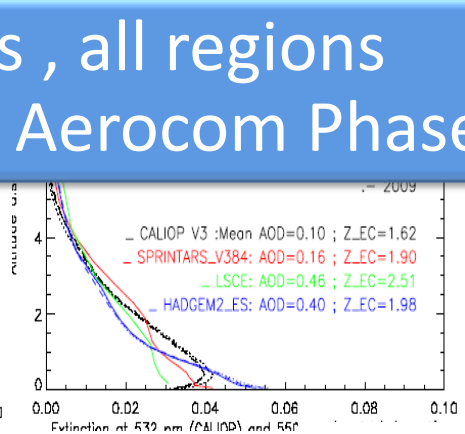
Is the vertical profile form captured?
AOD Normalized Profile for CALIOP and Model

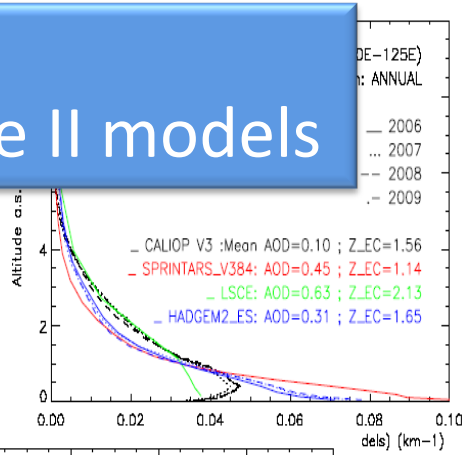


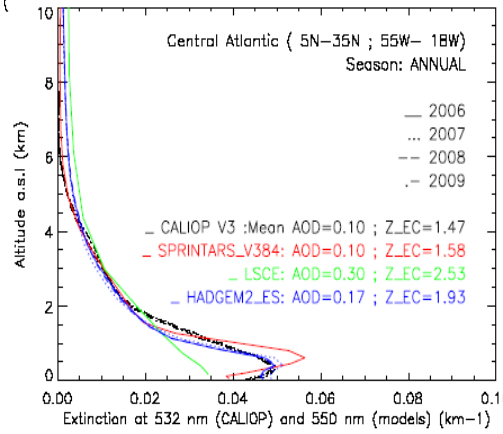
AOD Normalized Profiles , all regions
CALIOP against the new Aerocom Phase II models

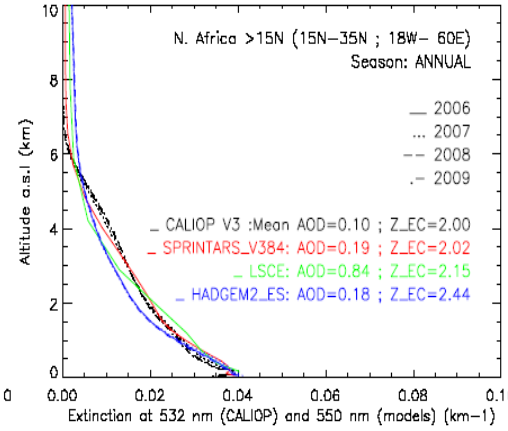


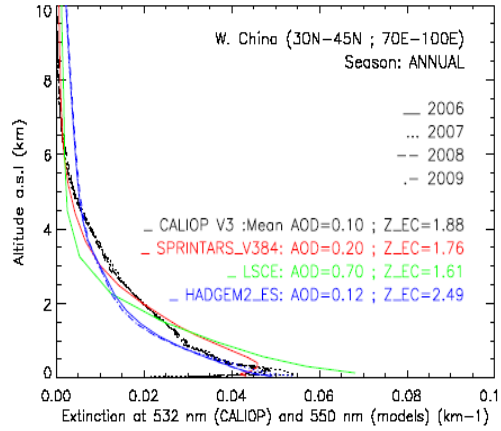


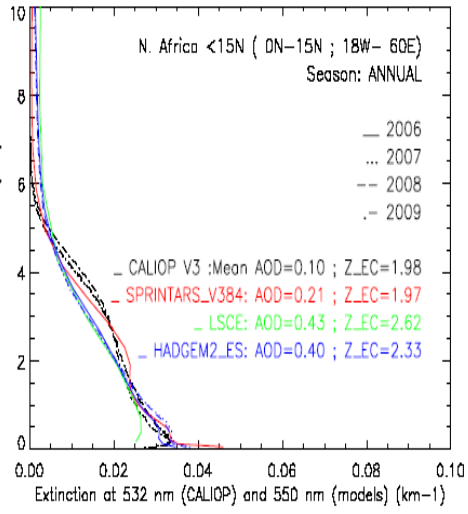


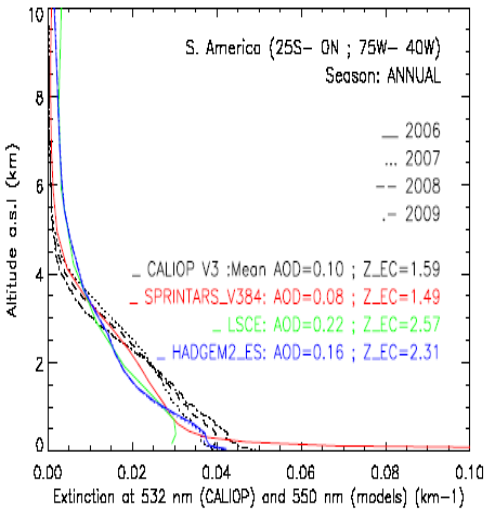


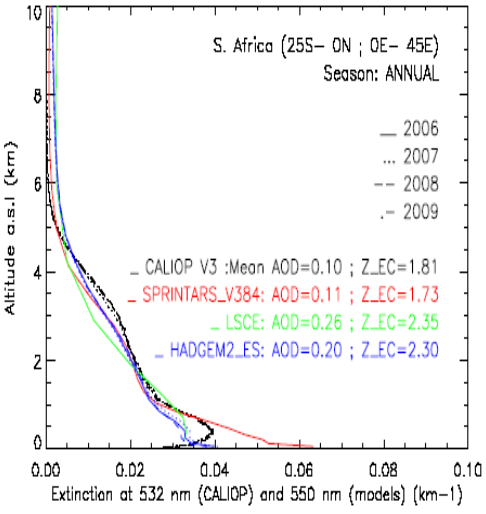


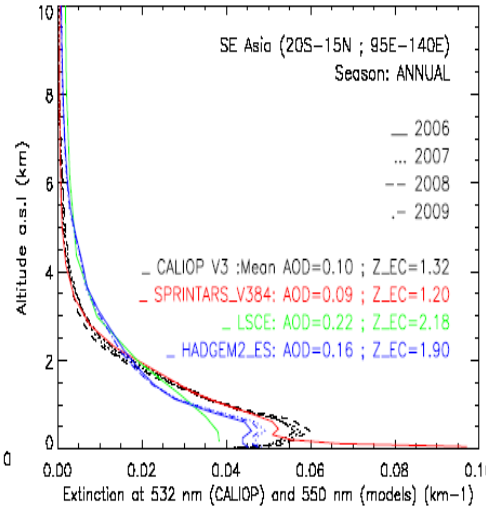




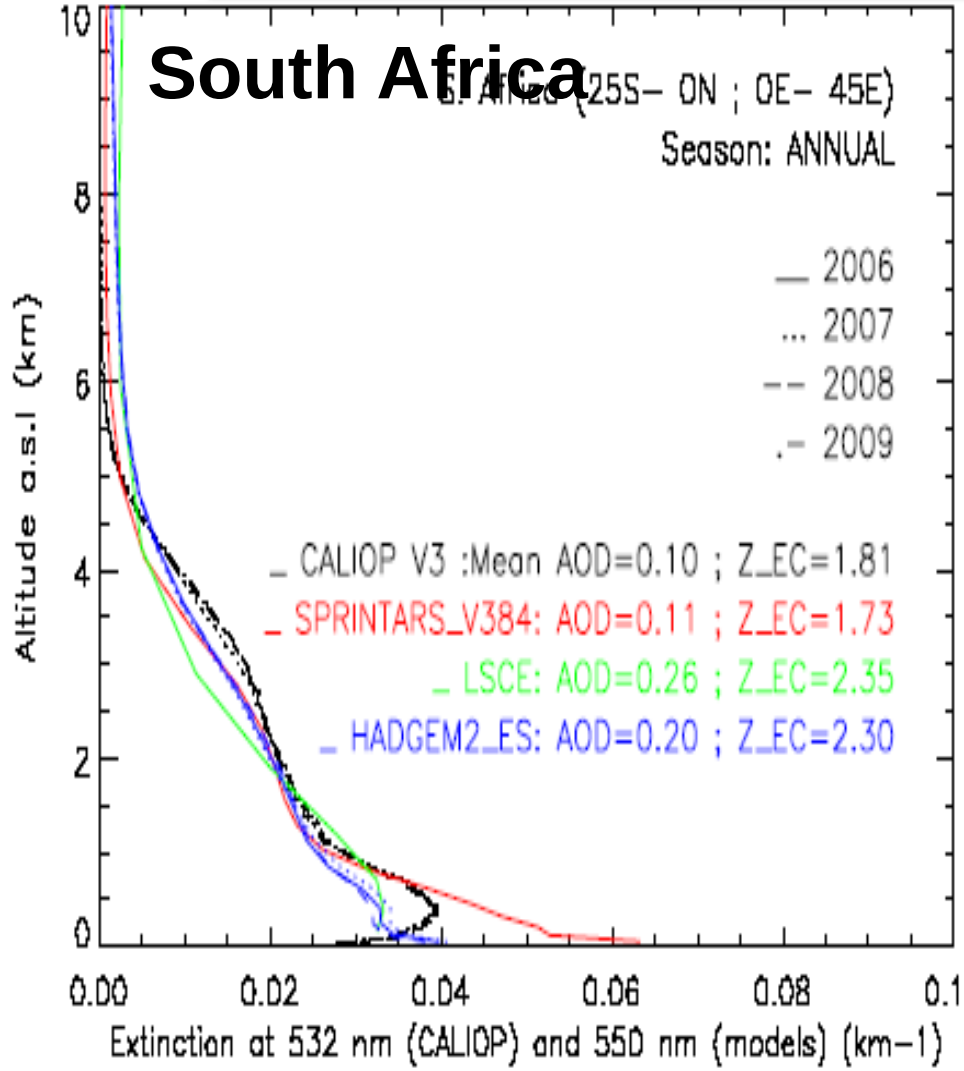


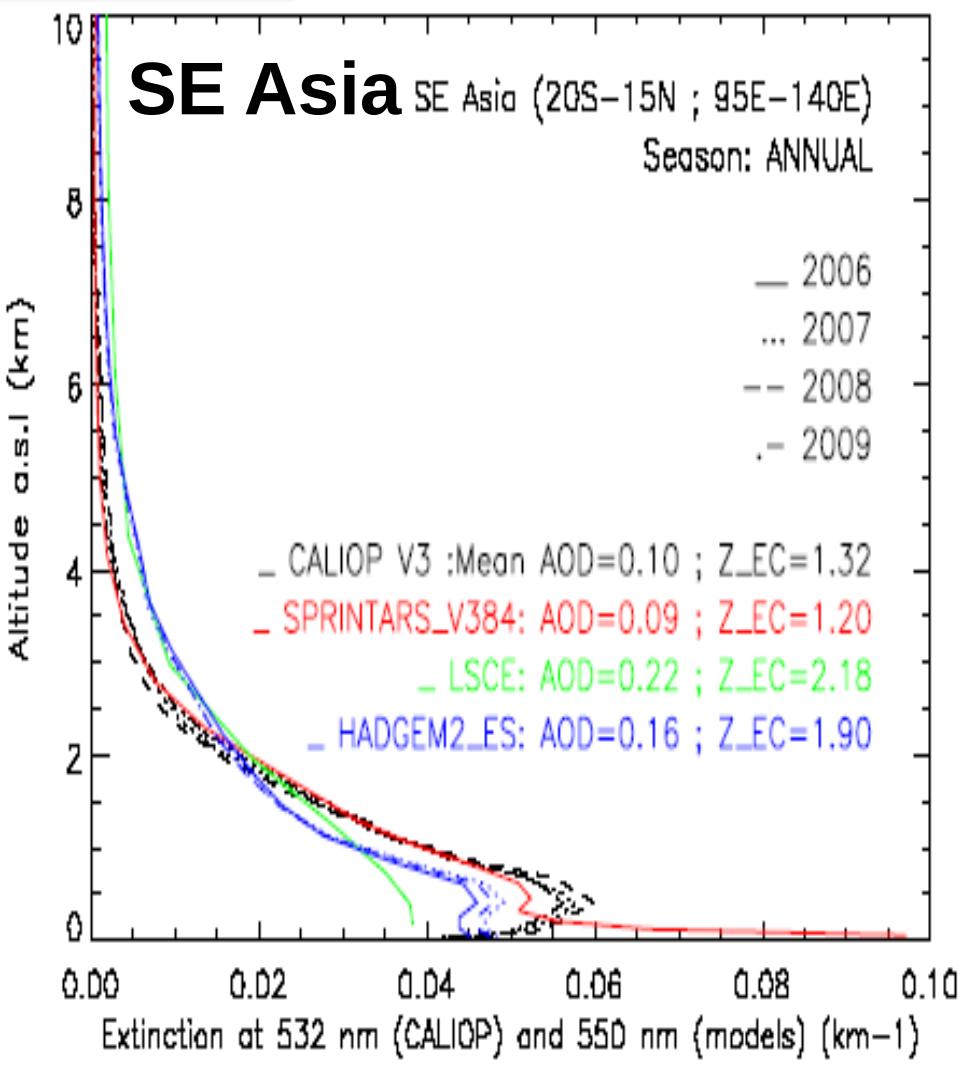






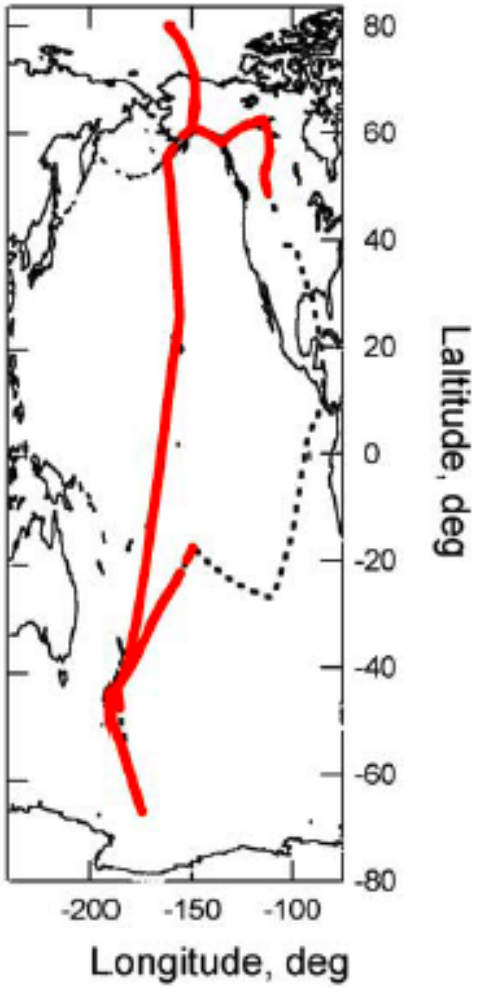
AOD Normalized Profiles
CALIOP against Aerocom Phase II





HIPPO flight campaign vs Aerocom models Black Carbon

Schwarz et al. GRL 2010



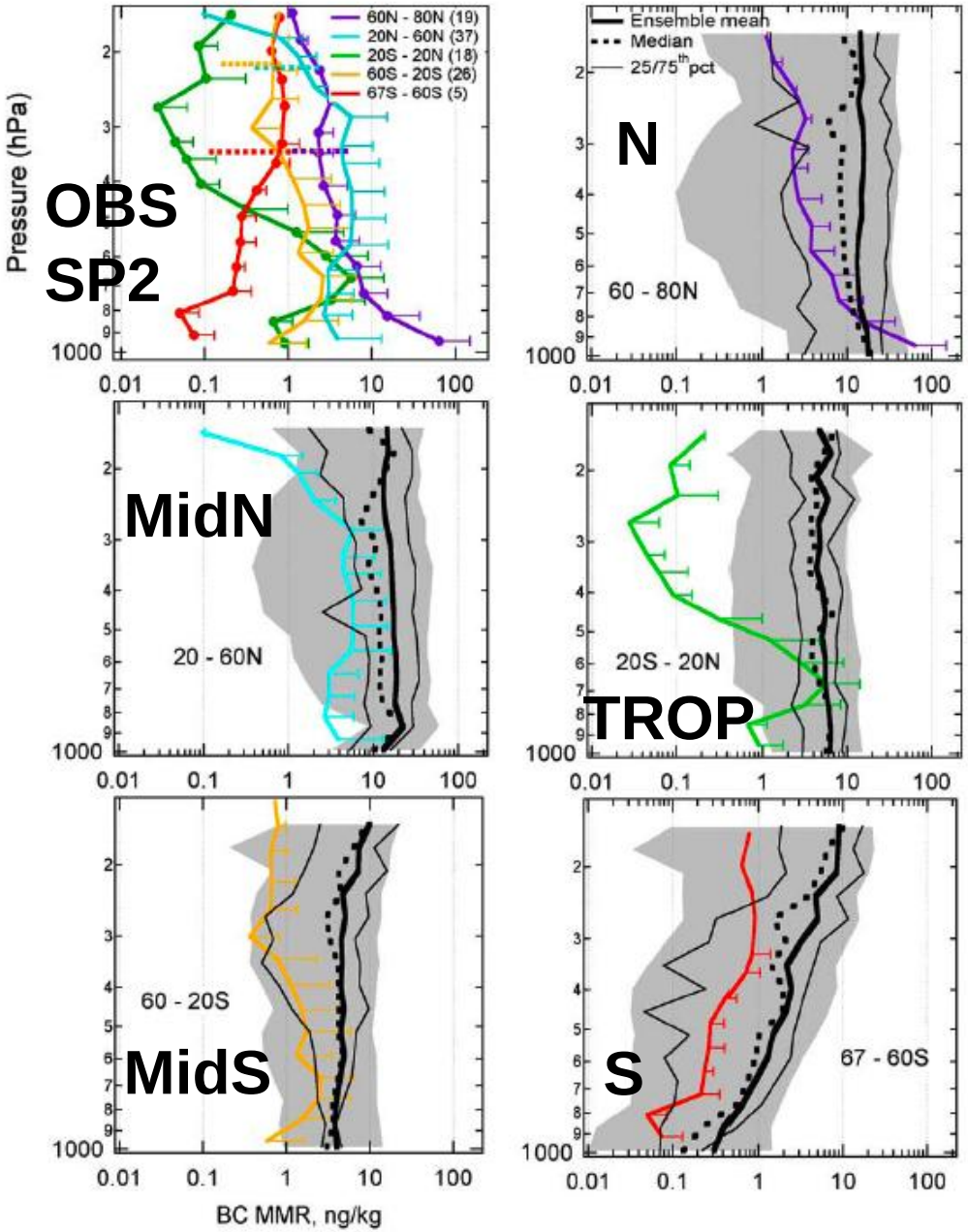
N

MidN

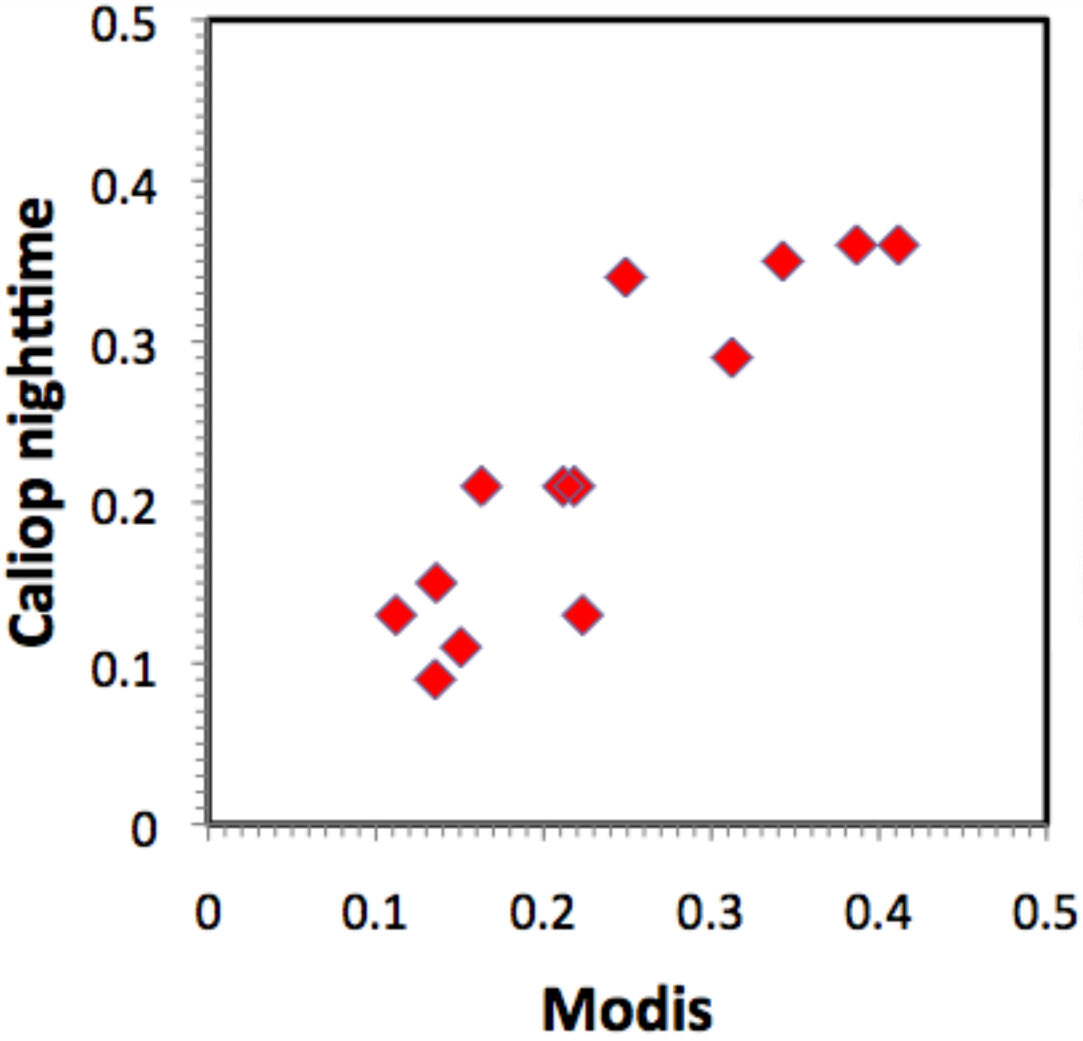
TROP

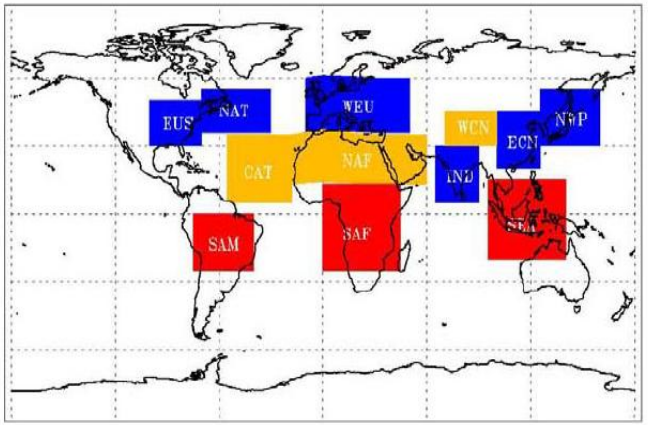
MidS

S

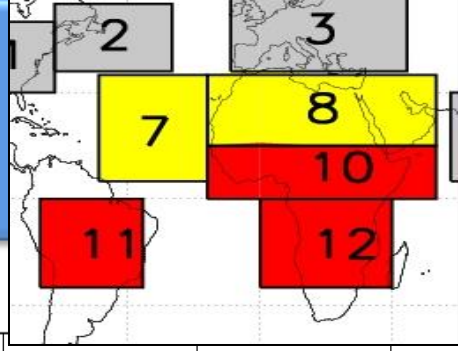


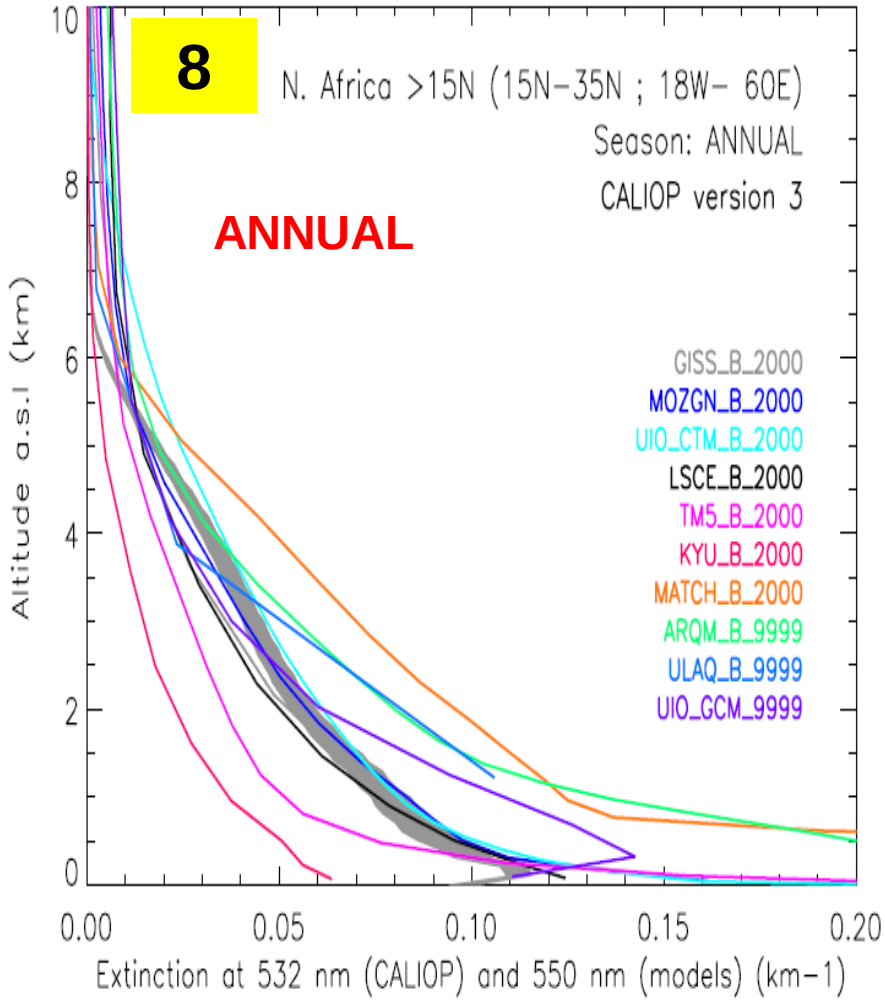
Is there a quantitative profile comparison possible? Comparison of AOD Regional Averages of CALIOP and MODIS 2007-2009 averages per large region

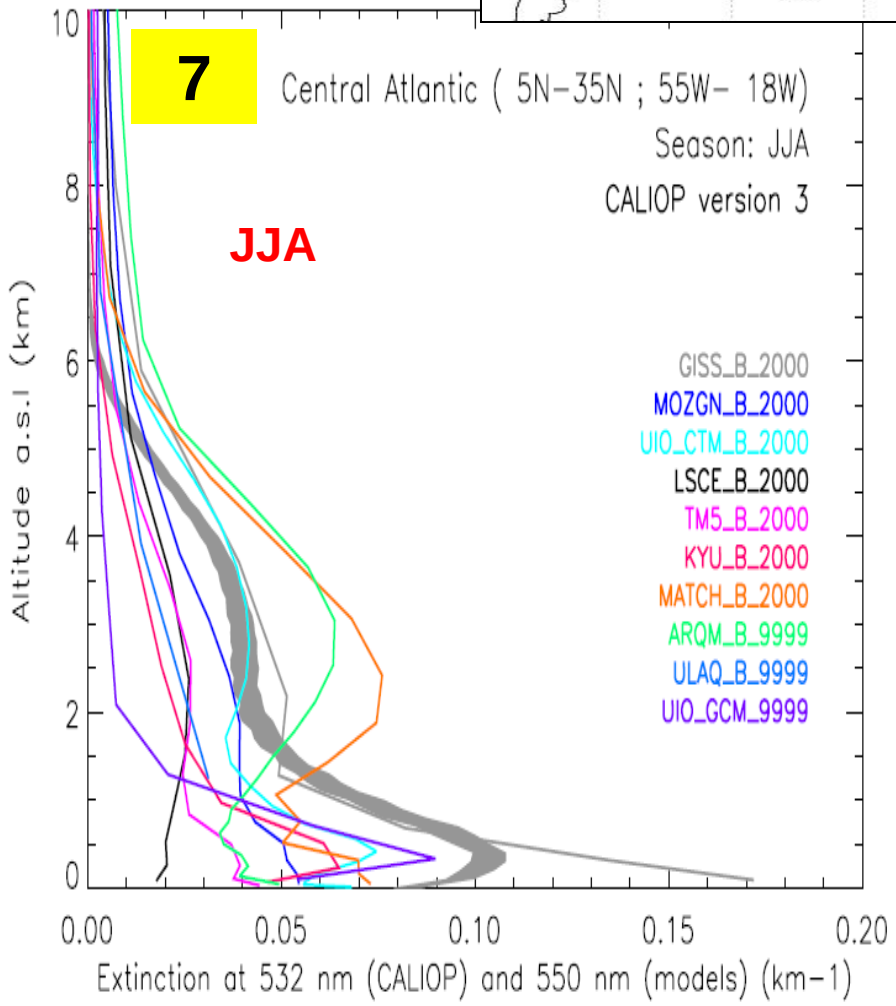




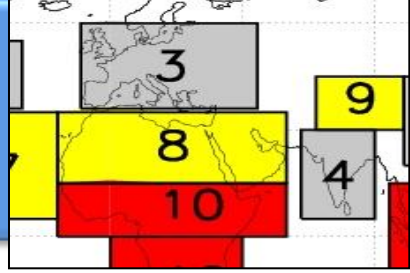
Caliop (07-09) vs Aerocom models (00)
Northern Africa versus Central Atlantic

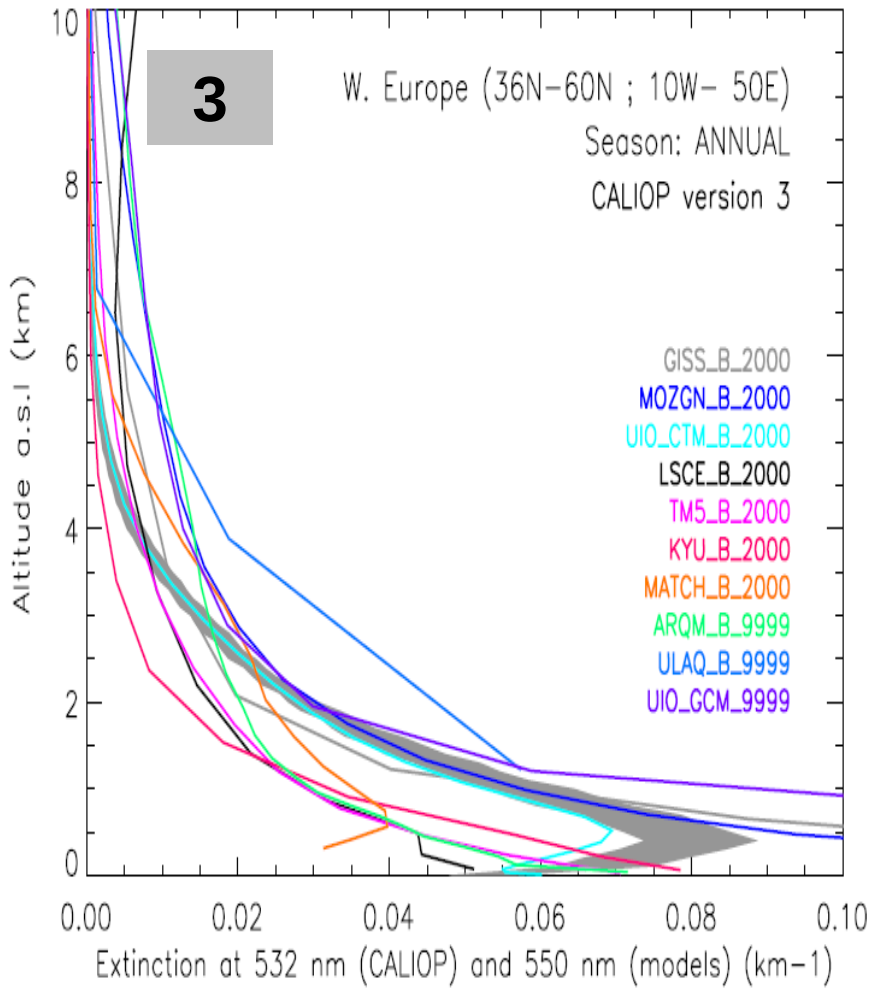


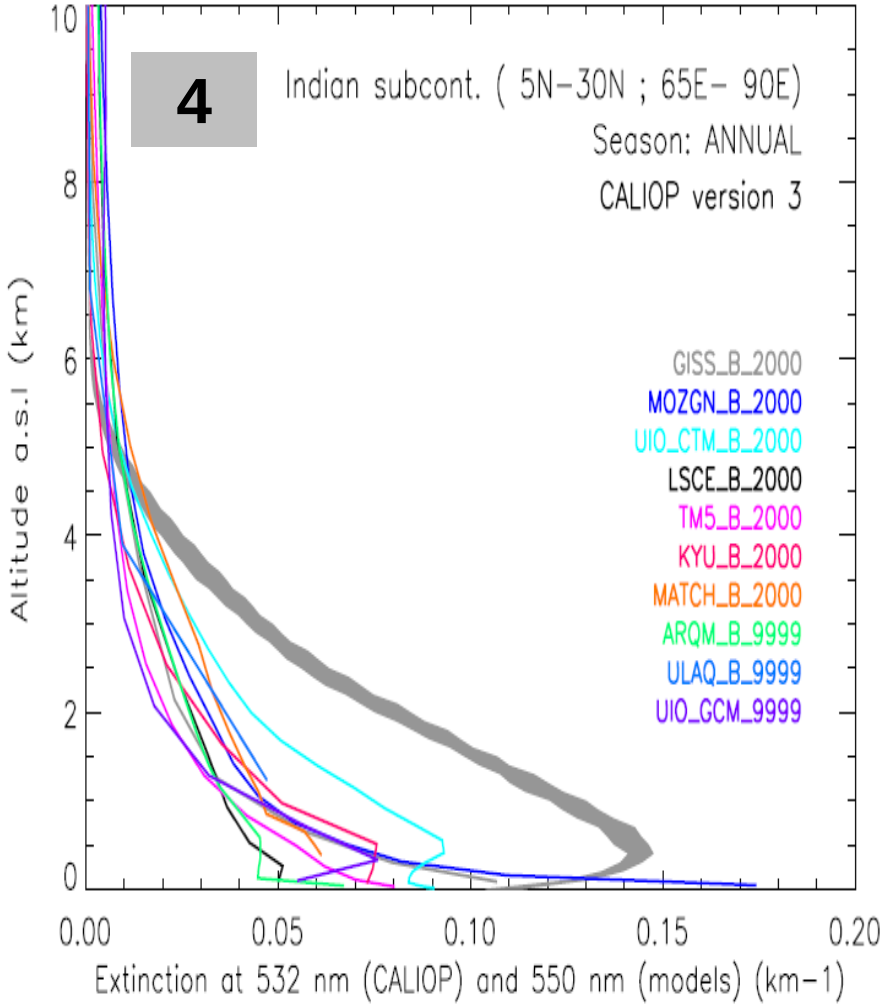




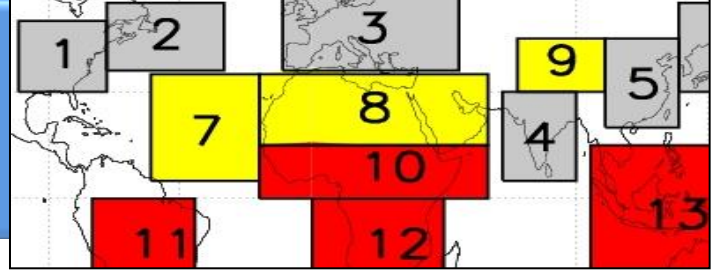
Caliop (07-09) vs Aerocom models (00)
Western Europe and Indian subcontinent

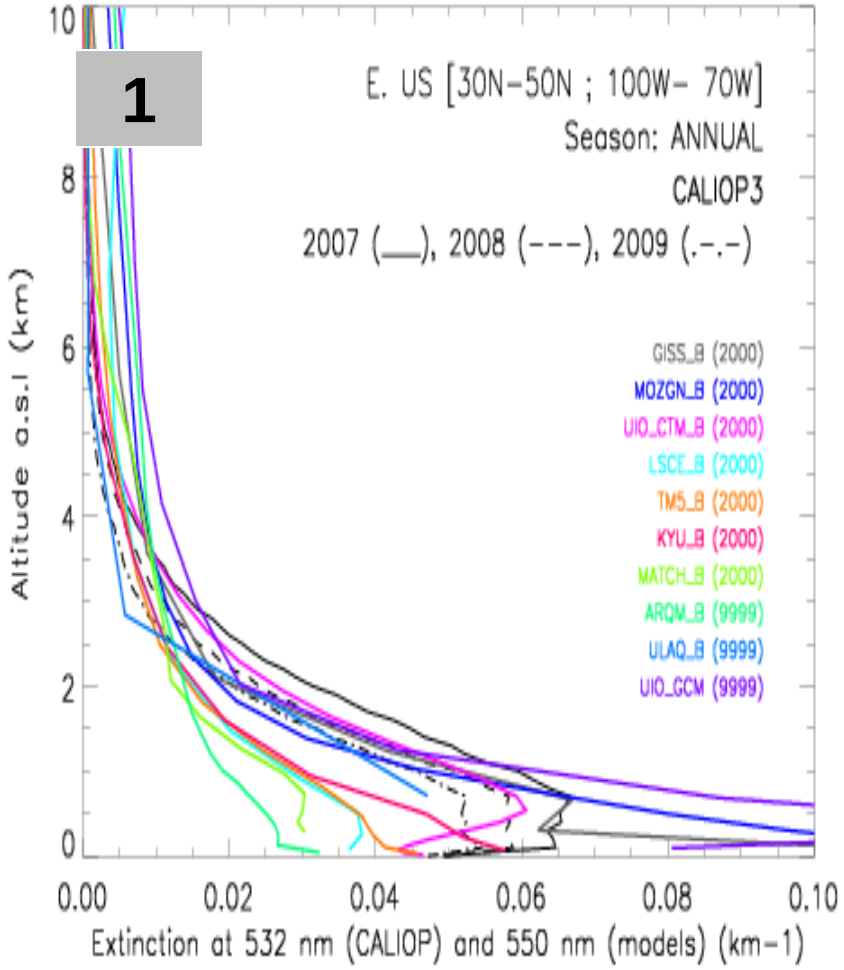


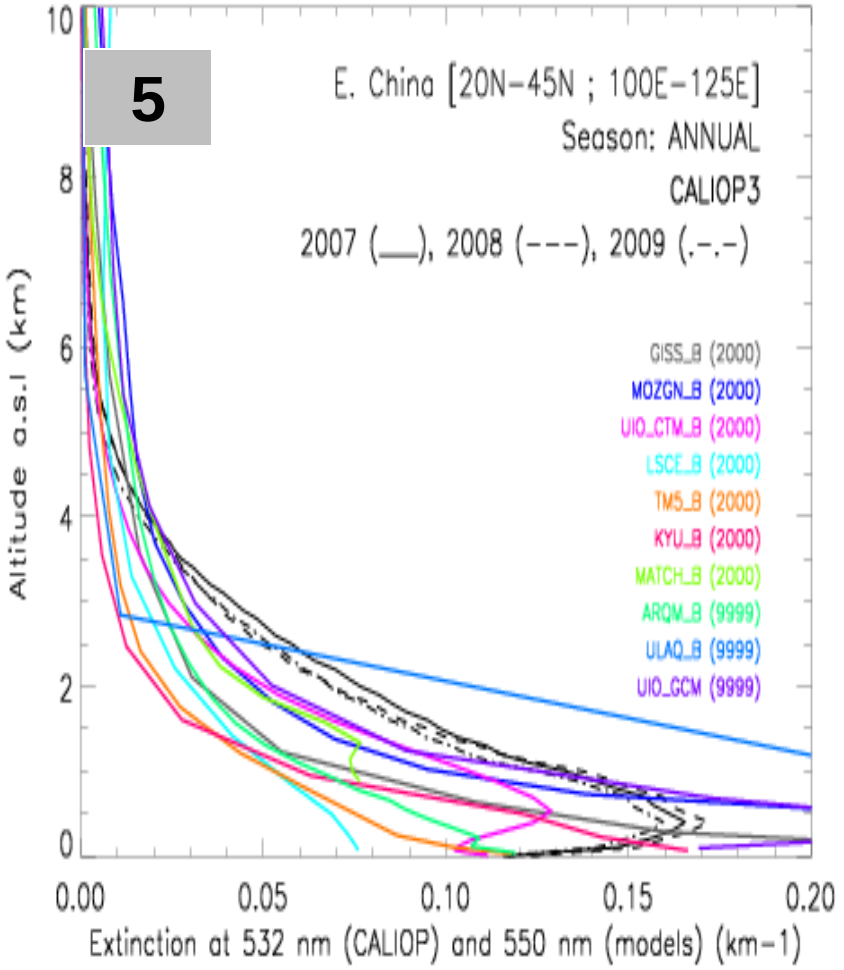




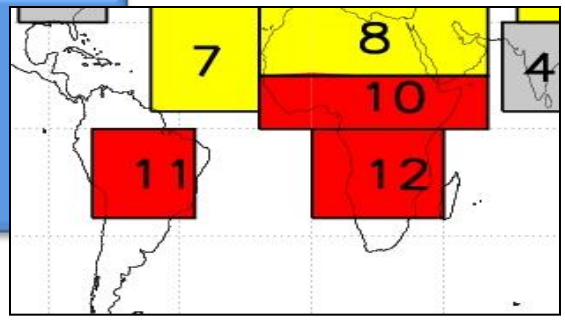
Caliop (07-09) vs Aerocom models Eastern US and Eastern China

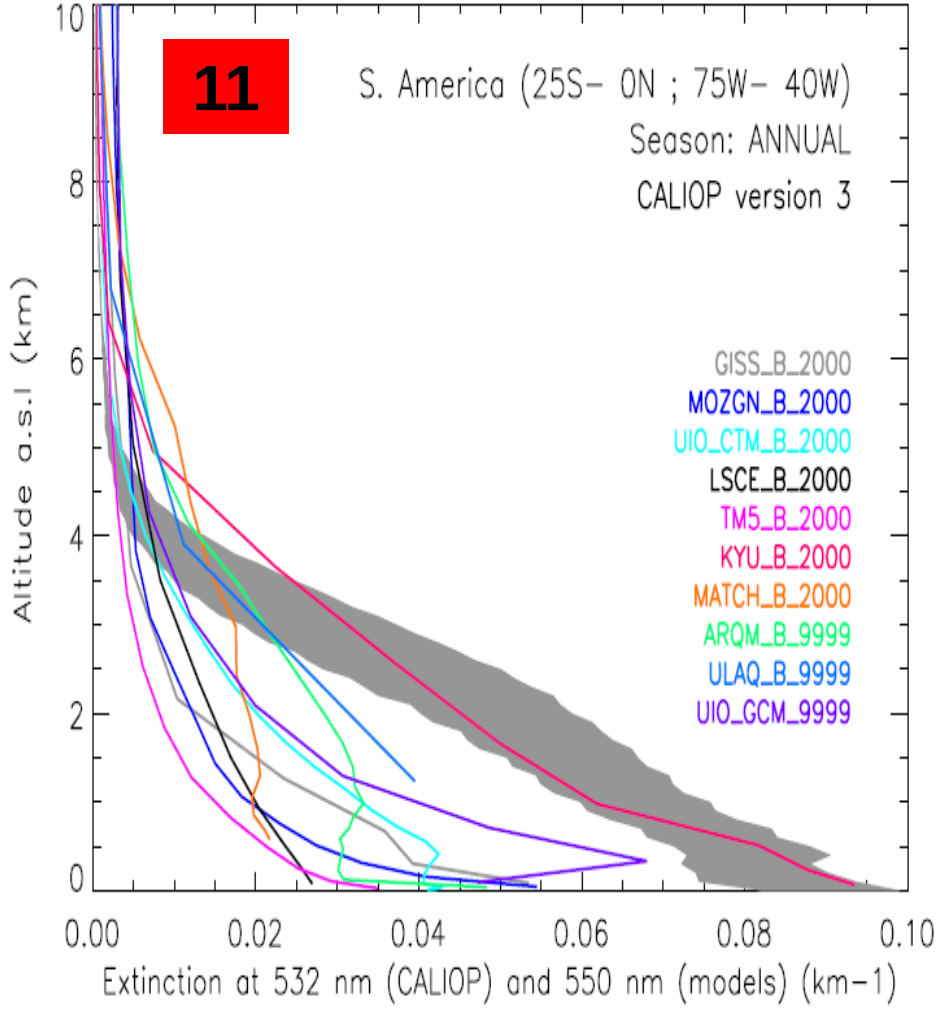


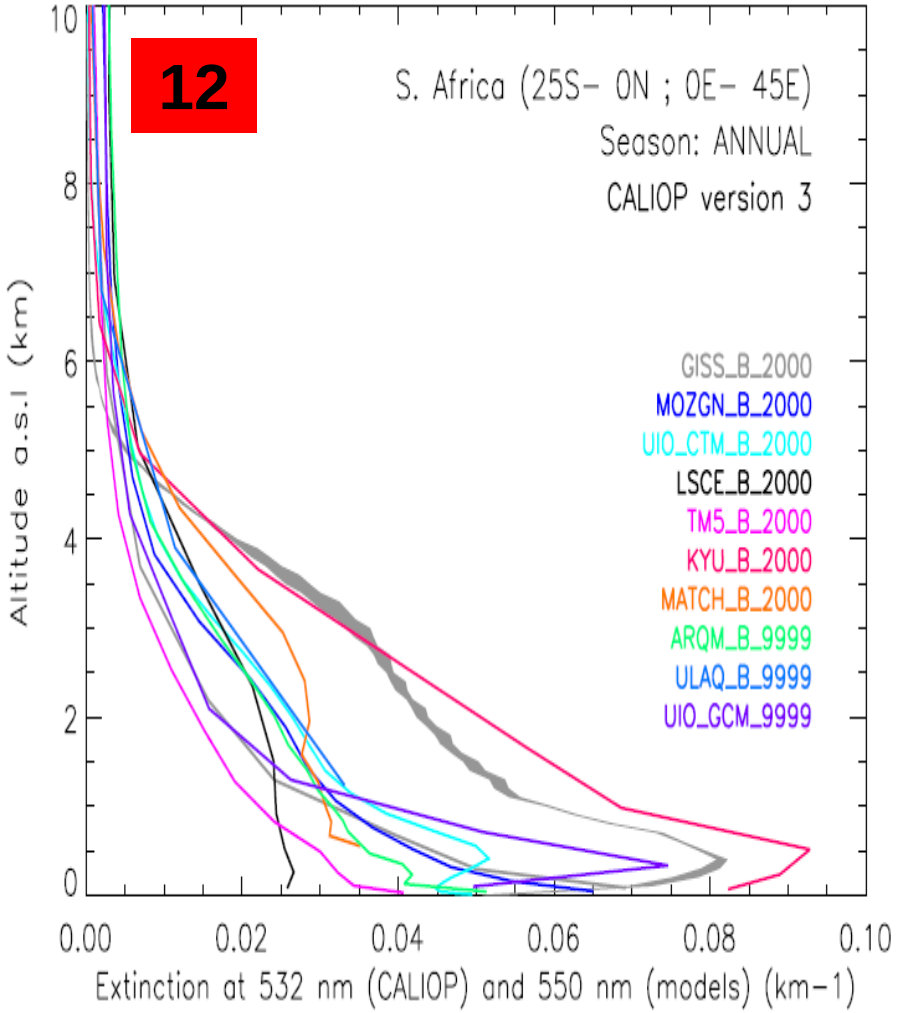




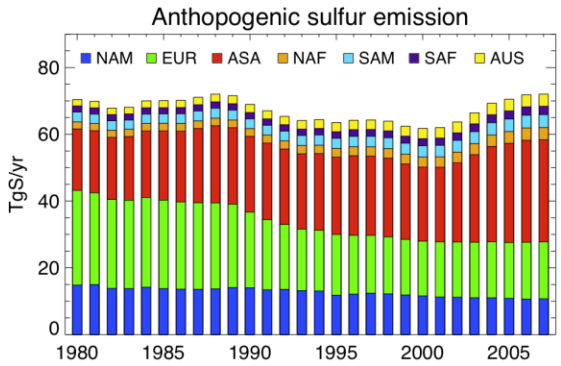
Caliop (07-09) vs Aerocom models (00)
South America & South Africa

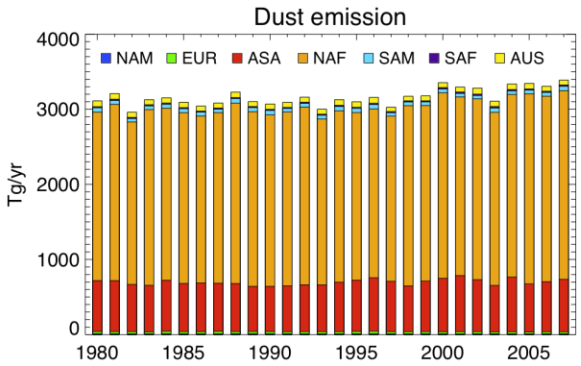


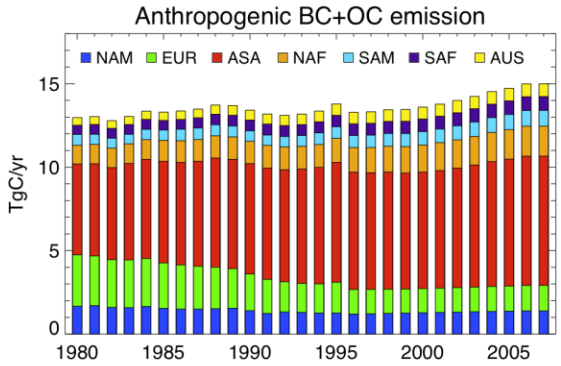


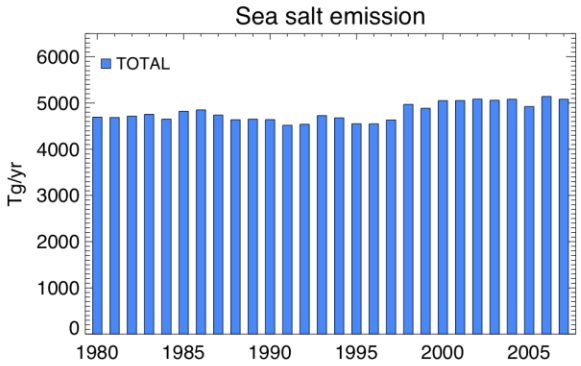


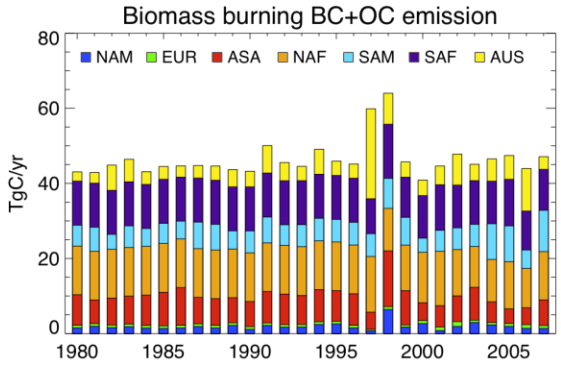
Anthropogenic and natural emissions of aerosols and precursors – 1980 to 2007

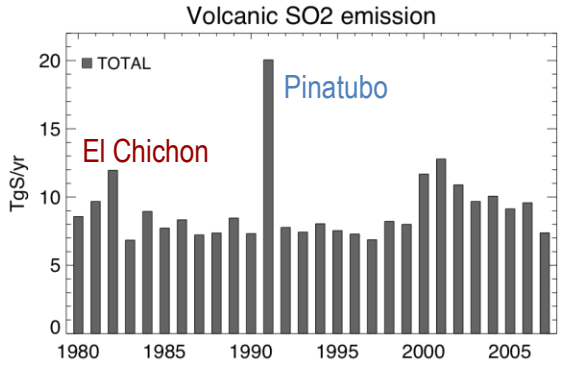


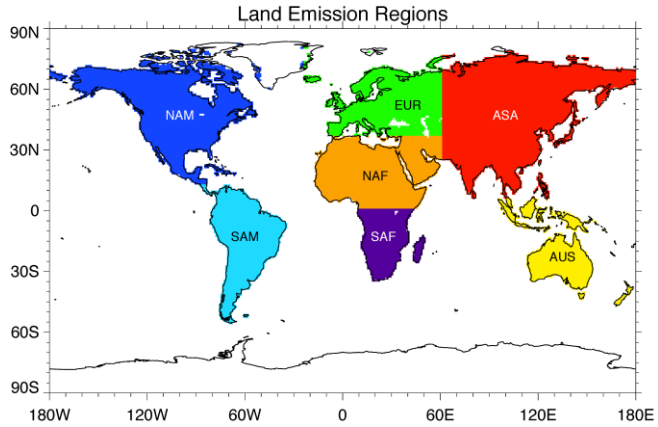












Anthropogenic emissions:

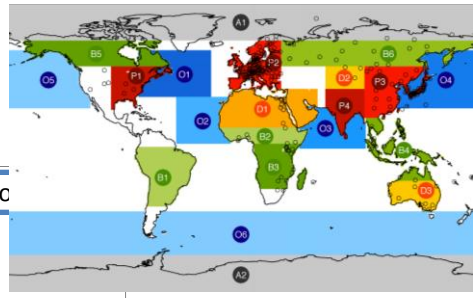
- North America and Europe – decreased
- Asia and other regions – increased

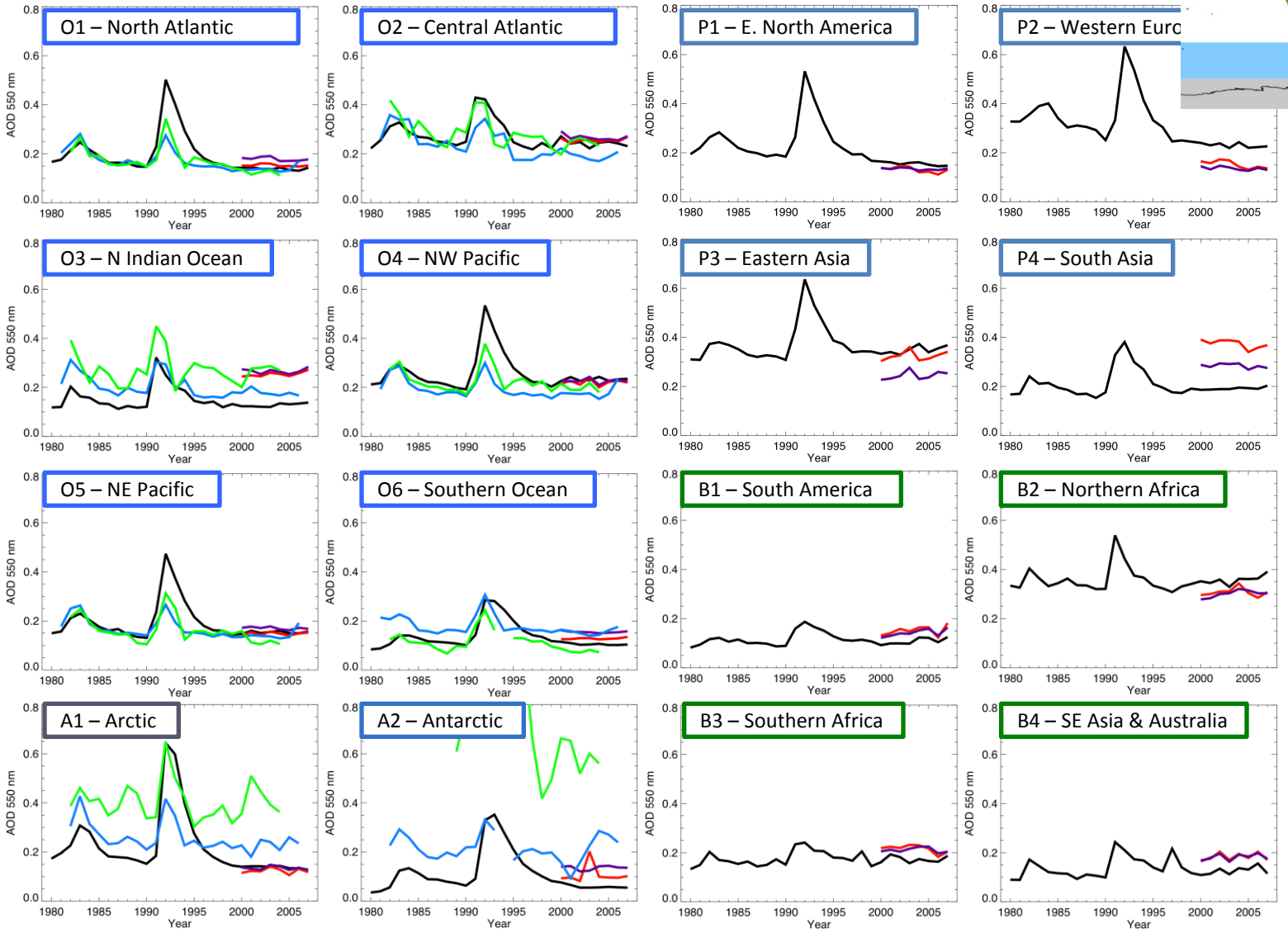
Biomass burning and natural emission:

- Varying from year to year (and place to place)

Courtesy Mian Chin

Multi-year variations of AOD – Regional





GOCART-ind.

AVHRR-GISS

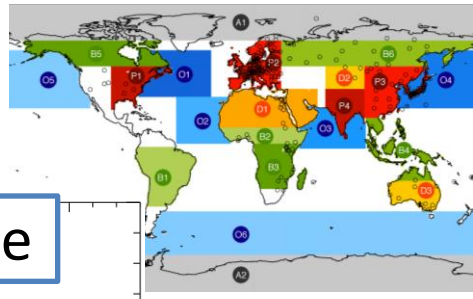
AVHRR-NOAA

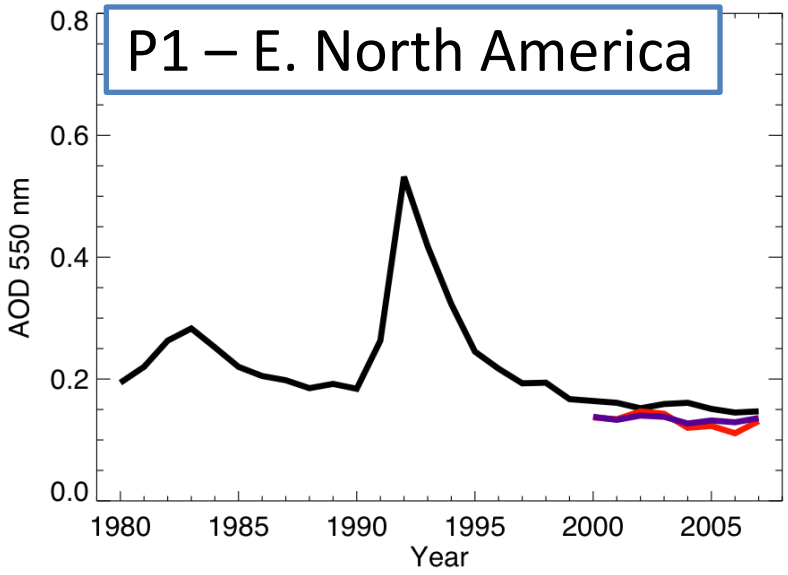
MODIS

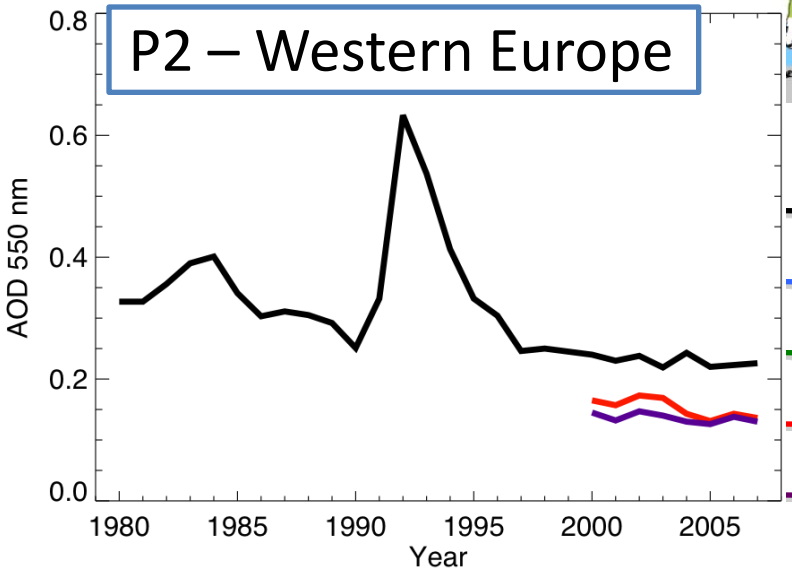
MISR

Courtesy Mian Chin

Multi-year variations of AOD – Regional







GOCART-ind.

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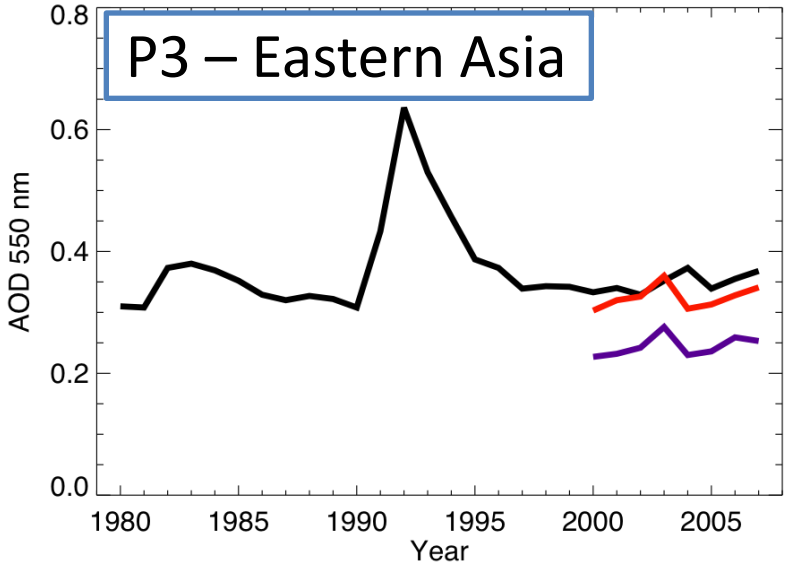

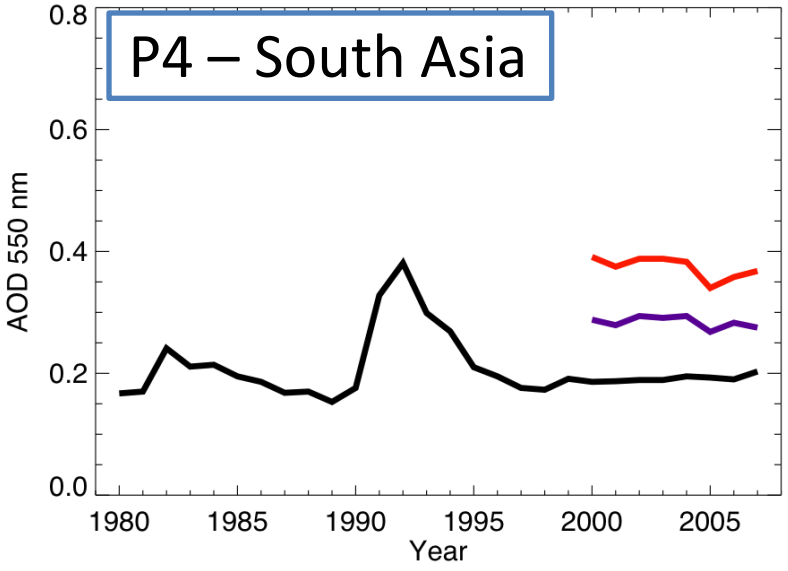

Courtesy Mian Chin

Challenges

- Regional/vertical absorption distribution
- Anthropogenic fraction of scattering and absorbing aerosols
- Absorption above clouds
- Consistent modeling
- Sampling bias
- Emission trends
- …..Aerosol-cloud interactions

Summary

Summary

What we can hang on the A-train as success:

- Assimilation results
- Regional aerosol emission verification
- Anthropogenic scattering aerosol
- Aerosol vertical distribution evaluation
- Large confidence in individual satellite products (type, height, fine fraction, aod, etc)
- Constrains forcing estimates from models in many ways and via multiple parameters

THANK YOU A-train

Next Aerocom workshop 3-7 October, 2011
Hosted by Kyushu University, Japan